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Effect of different recovery methods in strength training on performance and perceived exertion

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ABSTRACT

Objective: The study verified the acute influences of distinct recovery methods between sets on repetition performance and rate of perceived effort.

Method: Twenty six trained men (20.61 ± 2.95 years; 73.72 ± 5.91 kg; 175.00 ± 5.14 cm; $9.54 \pm 3.86\%$ Fat) performed test and re-test of ten repetitions maxims, on non-consecutive days, for the bench press exercise. Four sets of ten repetitions maxims on bench press were performed with 2 min of rest between sets for distinct recovery methods: passive recovery and active recovery (run performed on a treadmill at 45% of maximum oxygen consumption).

Results: No differences were found between the passive recovery (25.50 ± 3.13) and the active recovery (26.07 ± 2.46) for the total number of completed repetitions ($p = 0.181$). Additionally, the area under the curve did not show any difference between passive recovery (47.05 ± 6.98 reps min^{-1}) and active recovery (48.03 ± 5.46 reps min^{-1}). Important reductions were observed for each subsequent set for both recoveries methods ($p = 0.0001$). The perceived effort data shown important increase from the second set for passive recovery ($p = 0.0001$) and active recovery ($p = 0.001$).

Conclusion: No differences were observed between different recovery methods.

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Efecto de diferentes métodos de recuperación en entrenamiento de fuerza en la ejecución y percepción del esfuerzo

RESUMEN

Objetivo: El estudio verificó la influencia de los métodos de recuperación entre series en el desempeño de las repeticiones y la percepción subjetiva de esfuerzo.

Método: Veintiséis hombres entrenados (20.61 ± 2.95 años; 73.72 ± 5.91 kg; 175.00 ± 5.14 cm; $\%G = 9.54 \pm 3.86\%$) realizaron el test y un retest de la prueba de 10 repeticiones máximas, en días no consecutivos, para el ejercicio de *press* de banca. Se realizaron cuatro series en *press* de banca de diez repeticiones máximas con intervalo de dos minutos y con métodos de recuperación distintos: recuperación pasiva y recuperación activa (carrera continua en tapiz rodante al 45% del consumo de oxígeno máximo).

Resultados: No se encontraron diferencias entre la recuperación pasiva (25.50 ± 3.13) y la recuperación activa (26.07 ± 2.46) para el número total de repeticiones completadas ($p = 0.181$). Además, el área bajo la curva no muestra diferencias significativas entre recuperación pasiva (47.05 ± 6.98 reps/min) y

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recuperação ativa (48.03 ± 5.46 reps/min). Se observaron reducciones importantes durante las series sucesivas para ambas recuperaciones ($p = 0.0001$). Los datos de la percepción subjetiva de esfuerzo muestran aumentos importantes a partir de la segunda serie para la recuperación pasiva ($p = 0.0001$) y para la recuperación activa ($p = 0.001$).

Conclusión: No se observaron diferencias entre los distintos métodos de recuperación.

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Efeito de distintos métodos de recuperação no treinamento de força sobre o desempenho e percepção subjetiva de esforço

R E S U M O

Palavras-chave:
Educação física e treinamento
Força muscular
Levantamento de peso

Objetivo: O estudo verificou a influência de diferentes formas de recuperação entre séries, no desempenho das repetições e percepção subjetiva de esforço.

Método: Vinte e seis homens treinados (20.61 ± 2.95 anos; 73.72 ± 5.91 kg; 175.0 ± 5.14 cm; $\%G = 9.54 \pm 3.86$) realizaram teste e reteste de dez repetições máximas no supino horizontal, em dias não consecutivos. Foram executadas quatro séries no supino horizontal para dez repetições máximas, com intervalo de dois minutos e com diferentes procedimentos de recuperação: recuperação passiva e recuperação ativa (corrida realizada em esteira ergométrica a 45% do consumo máximo de oxigênio).

Resultados: Nenhuma diferença foi observada entre a recuperação passiva (25.50 ± 3.13) e a recuperação ativa (26.07 ± 2.46) para o número total de repetições completadas ($p = 0.181$). Adicionalmente, a área sob a curva não apresentou diferenças significativas entre a recuperação passiva (47.05 ± 6.98 reps/min) comparada com a recuperação ativa (48.03 ± 5.46 reps/min). Reduções importantes ocorreram durante as séries subsequentes para ambas as recuperações ($p = 0.0001$). Os dados da percepção subjetiva de esforço apresentaram importantes elevações a partir da segunda série para a recuperação passiva ($p = 0.0001$) e para a recuperação ativa ($p = 0.001$).

Conclusão: Concluímos que não ocorreram diferenças entre os distintos métodos de recuperação.

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Introduction

Resistance training (RT) has been widely recommended as an effective strategy for improving muscular fitness. It is already well established that a well-designed RT program might promote progressive increases in strength, power and muscular endurance of regular practitioners.^{1,2} Several investigations have shown that manipulations of different methodological variables like the rest periods between sets, will trigger different responses in neuromuscular, metabolic and hormonal system.^{1,3-5} Recently, a great number of experiments have investigated the direct relationship of rest period between sets and repetitions performance.⁶⁻¹¹

However, although recent studies on the effects of the rest interval between sets provide new tools for RT prescription, there is little evidence related to distinct rest methods, for example, the implementation of active (AR) or passive recovery (PR) between sets.^{6,12} Specifically, Hannie et al.¹² analyzed the influences of different recoveries between sets on the bench press exercise performed with 65% of a maximum repetition (RM) (15-RM) to failure in 15 untrained individuals. The AR was performed on an ergometer cycle at 45% of the peak of maximum oxygen consumption (VO_2max) for time fractions within 2 min of total rest. In contrast, the PR consisted of the entire amount of rest (2 min) consisting of a static recovery. Their results suggest that the AR promoted better recovery found on repetition performance during multiple sets progression when compared to RP.

After extensive research, we did not find any investigation that focused on the influences on repetition performance in multiple sets comparing PR and AR performed on a treadmill (ART) for resistance-trained individuals. Additionally, there are other known influences of different types of recovery for perception of exertion (RPE). These data can contribute to future prescription on distinct methods involving recovery between sets in order to optimize

the time-efficiency and training performance. Therefore, the aim of this study was to compare different recovery methods on repetitions performance and perceived exertion. It was hypothesized that there would not be a detrimental effect of active recovery protocol on performance, in part by optimizing blood lactate removal and thus, decreasing H^+ ions content that might reduce muscle acidosis.

Method

Subjects

Twenty-six trained men (20.61 ± 2.95 years; 73.72 ± 5.91 kg; 175.00 ± 5.14 cm; $\%Fat = 9.54 \pm 3.86\%$) with a minimum of six months in resistance training experience, and a relative strength > 1.25 kg/kg body mass in bench press. Before data collection, all subjects read and signed the consent term, as suggested by Helsinki Declaration and World Health Association. All subjects reported no musculoskeletal injuries that could be aggravated with the test and/or interfere the results, and stated not to make use of any drugs or ergogenic aid. In addition, all subjects answer the Physical Activity Readiness Questionnaire (PAR-Q).¹³ The study was approved by the Ethics Committee of the Catholic University of Petrópolis (Petrópolis, RJ, Brazil).

Experimental design

After two familiarization weeks, implementing the selected exercise, with similar loads for each daily workout with four sets per session and 2 min of rest intervals, the subjects performed 10-RM test in bench press (Technogym, Casena, Italy). Briefly, the initial test was performed with previously stipulated load (suggested by each subject) and if any individual exceeded or were unable to

complete the number of repetitions for the proposed load range (10-RM), the load was adjusted and a new attempt was performed respecting a 5 min of rest period with a total of five attempts.¹⁴ In order to minimize possible load tests error, the following strategies were adopted: (a) standardized instructions were given before the test, in order to guide and prepare each subject; (b) the participants were instructed on the proper technique of the exercise, including performing it a few times without load to reduce a learning effect on the scores obtained; (c) the subjects were asked to maintain the a similar execution pattern for all attempts. In addition, in order to ensure proper technique, standardized instructions were given for the correct bench press form, and were reinforced for each individual before test execution.¹⁵ No rest was allowed between the concentric and eccentric phases. The warm-up consisted of two sets with 12 repetitions with 40% of their 10-RM bench press load 2 min before the attempts. A standardized verbal encouragement was performed for all subjects.¹⁶ After 48–72 h of the first day of the test, a retest was conducted following the same procedures as previously described. The higher 10-RM load successfully lifted by both test and retest was utilized on the experimental procedure.

48–72 h of strength test, all subjects completed the Yo-Yo test¹⁷ in order to verify the VO_2max of each participant. Briefly, the test lasted for 5–25 min and consists of repeating sprint shots of 20 m in progressive speeds dictated by indicative sounds from a CD player using the CD that came with the Yo-Yo tests kit (www.teknosport.com, Ancona, Italy). Between each sprint, the subjects had 5 s to recovery where they moved around a marker placed 2.5 m behind the finish line. The non-completion of the given sprint specified on two occasions resulted in the end of the test and the latest successfully completed distance was recorded as test result. The Yo-Yo test session was conducted in an air-conditioned establishment with temperature at 24 °C on a smooth surface and cones to determine the distance of 2 × 20 m. Before the actual test, all subjects performed a warm-up period, which consisted of the first three test running sprints. All subjects were already previously familiar with the Yo-Yo test procedures.

48–72 h after performing the VO_2max test, subjects underwent on two sessions, each containing four sets of 10-RM for the bench press with a stipulated 2 min of rest between sets. On the PR protocol, the subjects remained lying on the horizontal bench seat across all the rest period length (2 min). As for the ART protocol, participants went for the treadmill with an intensity of 45% of VO_2max found on previous tests. In order to determine the treadmill (Technogym Excite+, Casena, Italy) speed at 45% of the VO_2max intensity without inclination, a series of formulas suggested by American College of Sports Medicine¹⁴ were applied. Briefly, the VO_2max value (verified by Yo-Yo test) was used to calculate the 45% intensity by the following formula: $\text{VO}_2\text{max} = (\text{VO}_2 45\% - 3.5) + [3.5 \times 45\%] / 45\%$. Once the value of $\text{VO}_2 45\%$ was determined, the correspondent treadmill speed in meters per minute was calculated using the following formula: $\text{Speed} = ([\text{VO}_2 45\% - 3.5] / 0.2) \text{ m/min}$. After those calculations, in order to acquire the speed in km/h, the following formula was used: $\text{speed in km/h} = (\text{speed in m} \times \text{min}^{-1} \cdot 60) / 1000$. Then, the individuals were held for 1 min to 45% of VO_2max on treadmill. The total rest period length between each set for the ART protocol was 2 min.

After all testing procedures and calculations, the participants were selected in different recoveries (PR or ART) through the alternate entrance method. No attempt was made to control the repetitions velocity; however, subjects were instructed to use a smooth and controlled motion. The RPE was checked immediately after each set by the OMNI-RES scale with emphasis on local muscular fatigue.¹⁸ The OMNI-RES level zero was associated with no effort situation as the level 10 was related to the maximum effort experimented for the subjects. All participants were previously introduced with OMNI-RES, and they were instructed to apply the

scale in their workouts routines two weeks before the start collection. The number of repetitions in each set and RPE were recorded and all visits were conducted at the same time of the day for each subject.

Statistical analysis

In order to verify the reproducibility of the 10-RM test, the intra-class correlation test and the Student's paired *T* test were conducted. The two-way ANOVA was performed in order to verify possible differences in repetition number of subsequent sets using different types of recovery (PR and ART). If necessary, the Bonferroni post hoc test was used for multiple comparisons. To verify differences in the total number of repetitions completed with different recoveries, a Student's *T* test was conducted. The area under the curve (AUC) was calculated by the trapezoidal method and the Student's *T* test was used to compare the distinct rest protocols (PR and ART). Additionally, in order to determine the magnitude of the number of repetitions, the effect size was calculated for each set comparing to the initial sets. The limits proposed by Cohen¹⁹ were applied to determine the magnitude of treatment. To analyze the RPE, the Friedman's test was performed and, if necessary, a paired comparison was performed. To verify differences between the RPE on distinct recovery methods, the Wilcoxon test was applied. The significance adopted was $p \leq 0.05$ and statistical treatments were performed using the SPSS software version 21.0 (IBM, Inc).

Results

Excellent reproducibility in 10-RM loads in the test and retest was observed ($r = 0.97$; $p < 0.0001$). In addition, the paired Student *T* test did not show any significant difference between the 10-RM load tests ($p = 0.582$).

For the total number of repetitions completed in bench press exercise, no significant difference ($p = 0.181$) were observed between PR (25.50 ± 3.13 repetitions) and ART (26.07 ± 2.46 repetitions) as shown in Figure 1. In addition, the AUC did not show

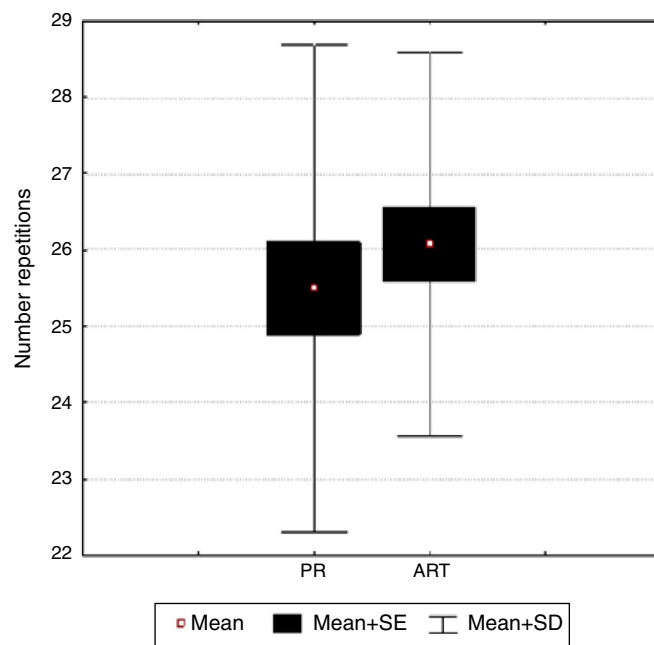


Fig. 1. Total number of repetitions for passive and active recovery performed on a Treadmill. ART: active recovery on treadmill; PR: passive recovery; SE: standard error; SD: standard deviation.

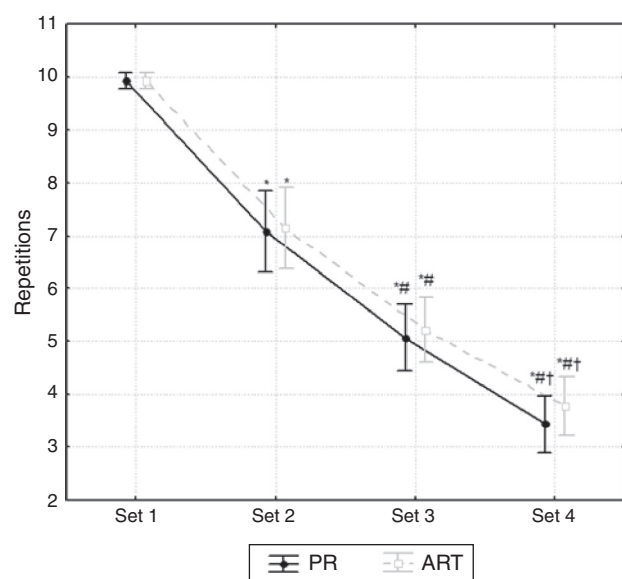


Fig. 2. Repetitions performance in each set for passive and active recovery (mean \pm standard deviation). * Significant difference to set 1; # significant difference to set 2; † significant difference to set 3; ART: active recovery on treadmill; PR: passive recovery.

Table 1
Effect size from the second set for passive and active recovery in trained men.

	Set 2	Set 3	Set 4
Passive recovery	11.09 (Large)	18.85 (Large)	25.23 (Large)
Active recovery performed treadmill	10.81 (Large)	18.30 (Large)	23.85 (Large)

any significant differences between PR (47.05 ± 6.98 reps min^{-1}) compared to ART (48.03 ± 5.46 reps min^{-1}).

The two-way ANOVA analysis did not present any significant difference for the interactions between the type of recovery and number of repetitions for subsequent sets ($p = 0.064$) and between distinct recovery conditions ($p = 0.46$). However, there was a clear significant reduction observed along the progression of subsequent sets for both recoveries ($p = 0.0001$). Specifically, the number of repetitions at each set was significantly lower from the second set when compared to the first set for both conditions (Fig. 2). Additionally, the effect of the size of the number of repetitions has been reported as large from the second set for both different types of recoveries (Table 1).

For the RPE, significant increases were observed from the second set for the PR ($p = 0.0001$) and ART ($p = 0.001$). A significant increase in RPE values was observed between the PR comparing to the fourth with the second set ($p = 0.016$) (Table 2).

Discussion

Among the main findings of this experiment, we highlight the lack of significant difference ($p = 0.181$) found on the total

Table 2
Perceived Exertion on each set for passive and active recovery in trained men (median).

	Set 1	Set 2	Set 3	Set 4
Passive recovery	8	9 ^a	10 ^a	10 ^{a,b}
Active recovery performed treadmill	8	10 ^a	10 ^a	10 ^a

Number repetitions.

^a Significant difference to set 1.

^b Significant difference to set 2.

number of repetitions performed between the distinct PR (25.50 ± 3.13 repetitions) and ART conditions (26.07 ± 2.46 repetitions). Furthermore, no difference was found on interactions between the type of recovery and the number of repetitions for the subsequent sets ($p = 0.064$). In addition, the AUC values presented no difference between PR (47.05 ± 6.98 reps min^{-1}) and ART (48.03 ± 5.46 reps min^{-1}). Both different recovery models (PR and ART) were implemented by a fixed 2 min of rest between sets and this design showed similar declines on performance from the second set compared to first set (1st > 2nd > 3rd > 4th set) and so on, as expected by the implementation of a short rest interval length.⁸⁻¹¹

Therefore, it became evident that ART did not affect negatively the repetitions performance or even the RPE values. In this manner, we can foresee that the implementation of a similar ART strategy may promote additional benefits related to the recommended total weekly aerobic activity,² and has the potential to optimize training duration,⁷ without negatively interfering on program efficiency and acute muscular strength performance. This type of strategy might help health professionals who do not possess the necessary time to conduct a training program with high volume and energy expenditure goals. Therefore, a well-elaborated ART design will add tools for athletes or even recreationally trained individuals' workouts for a great variety of goals such as health, quality of life or even esthetics to be achieved with great effectiveness.²

In a previous study conducted by Hannie et al.¹², the authors investigated the influence of AR and PR in strength training. In this investigation, the subjects rested for 2 min for both recoveries, however, when performed AR, part of this period was performed on cycle ergometer at 45% of peak VO_2max . The strength exercise analyzed was the barbell bench press and subjects were encouraged to try out as many repetitions they could lift with loads of 65% of 1-RM (15-RM). The authors observed a better recovery between sets, and found an increased production on isometric force within the AR when compared to PR. According to the authors, the AR performed on a cycle ergometer at 45% of VO_2max allowed a substantial removal of blood lactate and H^+ ions, thus reducing muscle acidosis. This strategy promoted significant better performance of the strength parameters when compared to PR.

Until Hannie et al.¹², no other publication had addressed the influences of an AR on repetitions performance and force production. The main differences from our study were the type of population investigated and the ergometer. For instance, the present study was conducted with trained individuals, that were used to utilize loads near to 10-RM on their regular routines. Additionally, we chose the treadmill ergometer as the AR strategy. Our results diverge with those found by Hannie et al.¹² possibly by the very distinct repetition zone and intensity (10-RM and 15-RM). Another crucial factor might have been the type of ergometer chosen. For instance, the intensity although the same (45% VO_2max), perhaps that when performed on a treadmill may not be sufficient to significantly reduce muscle acidosis and therefore enhance the repetitions performance. It appears that the previously expected reduced muscle acidosis status²⁰ was not enough to enhance performance on this maximal load range investigated (10-RM). In addition, the very different type of population (trained and untrained) might also have contributed to the different outcome.

In a recent investigation, Scudese et al.⁶ analyzed the influences of distinct recovery methods (PR and AR) within a fixed pre-stipulated 2 min of rest between four sets of the barbell bench press exercise for 10-RM in trained men. The PR consisted of subjects lying on the bench for the full 2 min of rest. For the AR, subjects performed rhythmical movements resembling the execution of bench press for the primary muscle with a pace controlled by a metronome. Similar to our findings, the authors found no differences on bench press performance for both AR and PR strategies.

While there were increased values of the RPE observed for both methods of recovery throughout the consecutive sets, higher values were found for the AR compared to PR for the third and fourth sets. These data converge in part with our investigation, since there was a progressive reduction in the number of sets to both recoveries and no difference was found on exercise performance for the distinct rest strategies.

Recent studies have found significant reductions on repetitions performance over consecutive sets, mainly triggered and evidenced by short rest periods (i.e. 2 min).^{8,11} For instance, Senna et al.¹¹ compared repetitions performance of 10-RM intensity with different rest periods for multi and single-joint exercise. The results indicated that shorter rest intervals (such as 1 and 2 min) had greater impact on decreasing the repetition number for bench press. For machine chest fly, significant differences were found for rest periods of 1, 2 and 3 min compared to the longer 5 min. Both exercises presented progressive declines on repetitions performance of over consecutive sets. This study differed from ours mainly due to the implementation of only passive recovery between sets, however, similarly with the present investigation, authors observed progressive reductions for the repetition number when applying 2 min of rest between sets for trained men. With this in mind, we did not found any additional performance advantages when applying the ART due to the similar outcomes observed for both recoveries.

Recently, RPE has been implemented to verify the perceived intensity during strength training exercises and this information can be crucial in order to comprehend the very complex muscle fatigue panorama.¹⁸ For instance, when analyzing the experiment conducted by Scudese et al.⁶, the AR (performed for the same muscle area) caused higher elevations of the RPE during sets when compared to the static PR. However, as the ART in our experiment was conducted on a treadmill, these subjective increases have not been observed. The RPE elevations are usually a response to training strategies that require greater needs of anaerobic glycolysis in muscle area specifically required and thus compensating for incomplete phosphocreatine resynthesis. The emphasis of anaerobic glycolysis energetic system is associated with the accumulation of H⁺, therefore creating a decreased pH intracellular fluid environment. The result is an afferent response of chemoreceptors and nociceptors that can increase the effort perception. In addition, much like a cascade effect, the central nervous system responds to the increase in RPE by increasing the pulmonary ventilatory response and motor unit recruitment in order to overcome this constantly changing environment.¹⁸

Through our main findings, we can conclude that the inclusion of the ART does not affect repetitions performance and RPE compared to PR. On the other hand, individuals who have the objective of conducting training with loads near 10-RM and additionally aims to increase energy expenditure and optimize the duration of session, should consider applying this method (ART). However, in order to improve knowledge around distinct recovery methods, we strongly recommend future research focusing on other types of verification, such as blood lactate and electromyography in order to better comprehend the peculiarities of the reported phenomenon.

Ethical disclosures

Protection of human and animal subjects. The authors declare that the procedures followed were in accordance with the

regulations of the relevant clinical research ethics committee and with those of the Code of Ethics of the World Medical Association (Declaration of Helsinki).

Confidentiality of data. The authors declare that no patient data appear in this article.

Right to privacy and informed consent. The authors declare that no patient data appear in this article.

Conflicts of interest

The authors have no conflicts of interest to declare.

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